Appendix D

GLOSSARY OF REMEDIATION TECHNOLOGIES

This Appendix presents definitions and brief discussions of the innovative remediation technologies mentioned in the text of this Annual SITE Report. Established/conventional technologies (including pump and treat, stabilization, vitrification, incineration, and excavation/disposal) are being replaced by these state-of-the-art, typically more cost-effective technologies are also presented.

Innovative Remediation Technologies

BIOREMEDIATION uses microorganisms to degrade organic contaminants in either excavated or in situ soil, sludge, and solids. The microorganisms break down contaminants by using them as a food source or cometabolizing them with a food source. Land farming, biopiles, composting, and slurry-phase bioremediation are examples of ex situ applications. Bioventing is a common form of in situ bioremediation which uses extraction wells to circulate air through the ground, sometimes also pumping air into the ground.

CHEMICAL TREATMENT, also known as chemical reduction/oxidation, typically converts hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, or inert. The oxidizing agents most commonly used for treatment of hazardous contaminants in soil are ozone, hydrogen peroxide, hypochlorites, chlorine, chlorine dioxide, potassium permanganate, and Fentons reagent (hydrogen peroxide and iron). Cyanide oxidation and dechlorination are examples of chemical treatment. This method may be applied in situ or ex situ, to soils, sludges, sediments, and other solids, and may also be applied for the in situ treatment of groundwater.

IN SITU SOIL FLUSHING: large volumes of water, at times supplemented with surfactants, cosolvents, or treatment compounds, are applied to the soil or injected into the groundwater to raise the water table into the contaminated soil zone. Injected water and treatment agents are isolated within the underlying aquifer and recovered together with flushed contaminants.

PHYTOREMEDIATION is a process that uses plants (roots, shoots, tissues, and leaves) to remove, transfer, stabilize, or destroy contaminants in soil, sediment, and groundwater. Phytoremediation applies to all biological, chemical, and physical processes that are influenced by plants and that aid in cleanup of the contaminated substances. Plants can be used in site remediation, both through the mineralization of toxic organic compounds and through the accumulation and concentration of heavy metals and other inorganic compounds from soil into aboveground shoots. Phytoremediation may be applied in situ or ex situ, to soils, sludges, sediments, other solids, or groundwater.

SOIL VAPOR EXTRACTION (SVE) is used to remediate the zone of soil which is unsaturated with contaminated groundwater. A vacuum is applied to the soil to control the flow of air and remove volatile and some semivolatile organic contaminants from the soil.

DUAL-PHASE EXTRACTION, also known as multi-phase extraction, uses a vacuum system to remove various combinations of contaminated groundwater, separate-phase petroleum product, and vapors from the subsurface. The system lowers the water table around the well, exposing more of the formation. Contaminants in the newly exposed unsaturated zone are then accessible to soil vapor extraction. Once above ground, the extracted vapors or liquid-phase organics and ground water are separated and treated.

SOLIDIFICATION/STABILIZATION (S/S) reduces the mobility of hazardous substances and contaminants in the environment through both physical and chemical means. The S/S process physically binds or encloses contaminants within a stabilized mass. S/S is performed both ex situ and in situ. Ex situ S/S requires excavation of the material to be treated, and the resultant material must be disposed. In situ S/S uses auger/caisson systems and injector head systems to add binders to the contaminated soil or waste without excavation, and the resultant material is left in place.

SOLVENT EXTRACTION uses an organic solvent as an extractant to separate organic and metal contaminants from soil. The organic solvent is mixed with contaminated soil in an extraction unit. The extracted solution is then passed through a separator, where the contaminants and extractant are separated from the soil. Organically bound metals may be extracted along with the target organic contaminants.

THERMAL DESORPTION: wastes are heated so that organic contaminants and water volatilize. Typically, a carrier gas or vacuum system transports the volatilized water and organics to a gas treatment system.

THERMALLY ENHANCED RECOVERY uses heat to increase the volatilization rate of organics and facilitate extraction. Volatilized contaminants are typically removed from the vadose zone using soil vapor extraction. Specific types of these thermally enhanced recovery techniques include Contained Recovery of Oily Waste (CROW™), radio frequency heating, conductive heating, steam heating, in situ steam stripping, hot air injection, dynamic underground stripping, in situ thermal desorption, and electrical resistance heating. Thermally enhanced recovery is usually applied to contaminated soil, but may also be applied to groundwater.

VITRIFICATION uses an electric current to melt contaminated soil at elevated temperatures (1,600 to 2,000°C or 2,900 to 3,650°F). Upon cooling, the vitrification product is a chemically stable, leach-resistant, glass and crystalline material similar to obsidian or basalt rock. The high temperature component of the process destroys or removes organic materials. Radionuclides and heavy metals are retained within the vitrified product. Vitrification may be conducted in situ or ex situ.

AIR SPARGING involves the injection of air or oxygen through a contaminated aquifer. Injected air traverses horizontally and vertically in channels through the soil column, creating an underground stripper that removes volatile and semivolatile organic contaminants by volatilization. Soil Vapor Extraction is usually implemented in conjunction with air sparging to remove the generated vapor-phase contamination from the unsaturated zone, Oxygen added to the contaminated groundwater and vadose-zone soils also can enhance biodegradation of contaminants below and above the water table.

TREATMENT BARRIERS, also known as permeable reactive barriers (PRBs) or passive treatment walls, are installed across the flow path of a contaminated groundwater plume, allowing the water portion of the plume to flow through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants by employing agents within the wall such as zero-valent metals, chelators, sorbents, and microbes. The contaminants are either degraded or retained in a concentrated form by the barrier material, which may need to be replaced periodically.

Conventional Remediation Technologies

For SOIL WASHING, contaminants are absorbed onto fine soil particle surfaces are separated from bulk soil in a water-based system on the basis of particle size. The wash water may be augmented with a basic leaching agent, surfactant, or chelating agent or by adjustment of pH to help remove organics and heavy metals. Soils and wash water are mixed ex situ in a tank or other treatment unit. The wash water and various soil fractions are usually separated using gravity settling.

VERTICAL ENGINEERED BARRIERS (VEBs) are subsurface barriers made of an impermeable material designed to contain or divert groundwater. VEBs can be used to contain contaminated groundwater, divert uncontaminated groundwater from a contaminated area, or divert contaminated groundwater from a drinking water intake or other protected resource.

INCINERATION involves the ex situ destruction of contaminated soil, sludge, and sediment in high temperature (1,800 - 2,200°F) combustion devices. A typical hazardous waste incinerator, diagrammed below, consists of a rotary kiln (primary combustion chamber), an afterburner (secondary combustion chamber), connected to an air pollution control system, all of which are controlled and monitored.

PUMP-AND-TREAT involves removal of contaminated groundwater is from the subsurface treatment, and discharge or reinjection, is one of the most widely used ground-water remediation technologies. The pump and treat remediation approach is used at about three-quarters of the Superfund sites where ground water is contaminated and at most sites where cleanup is required by the Resource Conservation and Recovery Act and state laws. It is often associated with treatment technologies such as Air Stripping and Liquid -phase Granular Activated Charcoal. Although the effectiveness of pump and treat systems has been called into question after two decades of use, this approach remains a necessary component of most ground-water remediation efforts and can be appropriate for both restoration and plume containment.